05-22-00

A1

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No. **0100.0000710**   Total Pages 46

First Inventor or Application Identifier Man, et al.

Title **APPARATUS FOR TESTING DIGITAL DISPLAY DRIVER AND METHOD THEREOF**

Express Mail Label No. EL559560750US

APPLICATION ELEMENTS	ADDRESS TO:	Assistant Commissioner for Patents

See MPEP chapter 600 concerning utility patent application contents.

Box Patent Application
Washington, DC 20231

1. ☒ Fee Transmittal Form
(Submit an original, and a duplicate for fee processing)

2. ☒ Specification   *Total Pages* 16
(preferred arrangement set forth below)
- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings *(if filed)*
- Detailed Description
- Claim(s)
- Abstract of the Disclosure

3. ☒ Drawings *(35 USC 113) Total Sheets* 5

4. Oath or Declaration   *Total Pages* 2
   a. ☒ Newly executed (original or copy)
   b. ☐ Copy from a prior application
        (37 CFR 1.63(d))
   (for continuation/divisional with Box 17 completed)
        [Note Box 5 below]
   i. ☐ DELETION OF INVENTOR(S)
   Signed statement attached deleting
   inventor(s) named in the prior application,
   see 37 CFR 1.63(d)(2) and 1.33(b).

5. ☐ Microfiche Computer Program *(Appendix)*

6. ☐ Nucleotide and/or Amino Acid Sequence
Submission *(if applicable, all necessary)*
   a. ☐ Computer Readable Copy
   b. ☐ Paper Copy (identical to computer copy)
   c. ☐ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. ☒ Assignment Papers (cover sheet & document(s))
8. ☐ 37 CFR 3.73(b) Statement   ☐ Power of
      (when there is an assignee)   Attorney
9. ☐ English Translation Document (if applicable)
10. ☒ Information Disclosure   ☐ Copies of
      Statement (IDS)/PTO-1449   IDS Citations
11. ☐ Preliminary Amendment
12. ☒ Return Receipt Postcard (MPEP 503)
        (Should be specifically itemized)
13. ☐ Small Entity   ☐ Statement filed in Prior
      Statement(s)   Application, Status still proper
                          and desired.
14. ☐ Certified Copy of Priority Document(s)
        (if foreign priority is claimed)
15. ☐ Other

16. If a CONTINUING APPLICATION, *check appropriate box and supply the requisite information:*

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP)   of prior application No:

Prior Application Information: Examiner   *Group / Art Unit:*
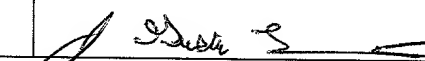
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Man, et al.   Examiner:

Serial No: Art Group:

Filing Date: 5-5-2000   Docket No: 0100.0000710

Title: APPARATUS FOR TESTING DIGITAL DISPLAY DRIVER AND METHOD
THEREOF

To the Honorable Commissioner
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

5

FILING OF A UNITED STATES PATENT APPLICATION

TITLE:

APPARATUS FOR TESTING DIGITAL DISPLAY DRIVER AND
10   METHOD THEREOF

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30

APPARATUS FOR TESTING DIGITAL DISPLAY DRIVER AND METHOD THEREOF

Field of the Invention

5   The present invention relates generally to testing digital graphics devices, and more specifically to an apparatus and method for verifying the integrity of digital graphics data.

Background of the Invention

The use of digital graphics data, or video data, to provide images to
10   display devices is becoming increasingly common with multimedia systems. As display device size, resolution, and color depth increase, however, the complexity of the display devices that render images, and the amount of time needed to test such devices also increases.

Traditional graphics/video output test is to connect panel or monitor
15   and user has to display pattern and looks for ringing, smearing and artifact. An advanced and expansive approach is used instrumentation to capture the signal and compare with output results. Such tests are relatively slow, and require significant hardware to capture and compare results.

Brief Description of the Drawings

Figure 1 illustrates, in block diagram form, an apparatus for testing a digital display driver;

Figure 2 illustrates, in flow diagram form, a method for testing a digital display driver;

Figure 3 illustrates, in flow diagram form, an alternative method for testing a digital display driver;

Figure 4 illustrates, in block diagram form, a more detailed illustration of the apparatus of Figure 1; and

Figure 5 illustrates, in block diagram form, the apparatus of Figure 1 implemented in a system.

Detailed Description of Drawings

In a specific embodiment of the present invention, a graphics device generates digital output data in response to a known input data. The resulting digital output data has an expected circular redundancy check (CRC) value. The generated digital output data is provided to a digital graphics output port associated with the graphics controller, which is thereby transmitted to a test apparatus over a digital graphics cable.

The test apparatus performs an analysis on the received digital graphics data. Subsequent to performing this analysis, the results are transmitted back to the graphics device over a serial link of the digital display cable. In a specific embodiment, the transmission of analysis data

5 between the test apparatus and the graphics device occurs over a non-video serial data node of the display connector that functions as a serial control interface.

The graphics device receives the transmitted analysis data, which is subsequently used to determine if the graphics device is operating properly.

10 This determination may be made the graphics device, or by a host system for further analysis. Specific embodiments of the present invention are described herein with reference to Figures 1-5.

Figure 1 illustrates a system 100 which includes a computing device 160, a graphics device (device under test -- DUT) 110, and a test apparatus

15 120.

The computing device 160 is typically a general-purpose computer, although other standard or custom computing devices can be used. The computing device 160 is connected to the graphics device 110 through the interface 170. In a specific implementation, the interface 170 is a peripheral

20 components interconnect (PCI) bus, or an accelerated graphics port (AGP) bus. Other standard and/or custom busses can be used as well.

The graphics device 110 is a device under test, such as a graphics controller mounted on printed circuit board. It will be appreciated by one of

ordinary skill in the art that the term graphics device is being used generically herein and applies to devices capable of generating digital video data. Specifically, the graphics device 110 provides digital data for display to an output port.

5   The term port refers to a set of one or more nodes having a common or associated function. Generally, the term node refers to conductive interconnect, often where a connection to another device is made, or to be made. For example, the connector 112 represents a graphics port because its individual pins have an associated function -- to support the transmission of

10   digital graphics data per a specific protocol, and it provides a connection to an external cable. In other embodiments, a port can include device pads, pins, and/or traces. In a specific embodiment, the pins of connector 112 are specified by Video Electronics Standards Association (VESA) DFP standard, which is generally used to connect to a flat panel display device

15   (not shown).

A cable 150 connects the digital graphics connector 112 to a digital graphics connector 122 of the test apparatus 120. Test apparatus 120 includes a serial module 122 and a CRC module 124. The operation of system of Figure 1 is further described with reference to the method of

20   Figure 2. Note that in an alternate embodiment, the connector 122 can be select to mate directly to the connector 112, thereby eliminating the need for a cable 150.

At step 201 of Figure 2, digital graphics data is provided to a digital video port of the graphics device 110. Generally, this digital graphics data is

generated by a graphics controller (not shown) associated with graphics device 110 in response to commands and/or data from the computing device 160. The types and/or components of digital data generated by the graphics device 110 include color components (Red, Green, Blue--RGB), and control

5   or synchronization components (HSYNCH, and VSYNCH). Furthermore, the digital data provided to the digital video port has an expected characteristic, such as an expected CRC value.

At step 202, a representation of the digital graphics data is received at a video port of the test apparatus 120. In one embodiment, the

10   representation of the digital graphics data includes differential signals.

At step 203, the CRC module 124, which is a test module, calculates a calculated characteristic, such as a CRC value, based on the received digital graphics data. In one implementation, the CRC value is calculated from received RGB color component values. In another embodiment, the CRC

15   value is calculated from received RGB color component values and HSYNCH and/or VSYNCH transitions. In another implementation, the generated value is a count indicating the number of received HSYNCH and or VSYNCH transitions.

At step 204, the calculated characteristic value(s) is provided back to

20   the graphics device using the serial data interface nodes of the digital graphics port 122.

At step 205, the calculated characteristic value is compared to the expected characteristic value to determine if the transmission was

successful. The comparison of step 205 can be performed by the graphics device 110, or by the computing device 160. In order for the computing device 160 to compare the calculated characteristic value with the expected characteristic value, the calculated characteristic value needs to be

5 transferred from the graphics device 110 to the computing device 160. By storing such information on the computing system 160, a log of each test can be maintained.

The implementation of the present invention described above can perform the CRC calculation while receiving the digital graphics data at full

10 speed. For example, by using an integrated circuit device, the CRC can be calculated at video data clock rates. For example, a clock rate of 165Mhz capable of supporting UXGA can be supported by using appropriate speed grade components. In addition, by transmitting CRC results back to the host 160, through the graphics device 110, the amount of overhead associated

15 with the test device 120 is reduced to the analysis logic and the logic needed to be a serial slave, and the need for visual scanning is eliminated.

In a specific implementation, the test device 120 can be mounted on an add-in board for the purpose of being housed in the computing device 160. The test device 120 can obtain power from any external source,

20 including a power node of a bus, or from a digital graphics node that provides power. Because an existing serial connection of the bus 150 is used to communicate the values calculated on the test device 120, expensive connections are avoided (i.e. PCI bus protocol support, or parallel port support is not needed).

Figure 3 illustrates an alternate method in accordance with the present invention. At step 301, a test indicator is provided to the graphics device 120 output port. The test indicator can be provided to the test module 120 over the serial data interface portion of the graphics port 112.

5   The test indicator is used to indicate the graphics data to be tested and/or the calculated characteristic to be calculated. For example, an 8-bit value, when provided to the test device 120, can indicate that the CRC module 124 is to calculate the CRC based on a specific color component (type) only. For example, referring to Figure 4, a value can be written to the

10   serial-in register 426 that only enables one switch of the switches 430. For example, the switch associated with accumulator 417can be enabled. As a result, the CRC value is based only on the red color component from demultiplexor 420. Alternatively, if the value written to the serial in register 426 enables the switches associated with accumulators 415-417, a CRC

15   value will be generated based on the red, blue and green color components.

In yet another embodiment, a value can be provided to register 426 that enables a switch associated with accumulator 418 or 419, the resulting value will represent the number of VSYNCH, or HSYNCH transitions respectively. Furthermore, a control value can be selected to include

20   HSYNCH and/or YSYNCH transitions in the CRC count with color component data. The value to be calculated by the CRC Module 124 is selected to calculate the calculated characteristic in the same manner that the expected characteristic was calculated.

By allowing the flexibility described, errors can be pin-pointed with greater accuracy. For example, where a full color component CRC value fails, the system can request individual color components be tested.

Steps 302-306 are analogous to step 201-205 of Figure 2, and are not repeated herein.

Figure 4, illustrates a more detailed embodiment of the CRC module 124, and the Serial module 122. The CRC module 124 demultiplexes the color component data and synchronization data from the received display data and clock signals.

In the embodiment illustrated, each of the color and synchronization component values are received by separate accumulators 415-419, which maintain running totals. The accumulators 415-419 can be reset and/or latched by control circuitry (not illustrated) which is capable of being implemented by one of ordinary skill in the art.

A switch bank 430 is controlled by a data value received at the serial module 122. When an accumulator's switch is closed, the accumulated value stored in its register is summed by adder 412 to any other selected accumulator values to generate the generated CRC value. Note that other specific computations can be made to the CRC value as needed. The calculated CRC value from the adder is sent to the serial module 122 for transmission.

One of ordinary skill in the art will recognize that the block diagram of Figure 4 illustrates a specific implementation that can also be considered a functional representation, and that many variations of the portions illustrated in Figure 4 can be implemented. For example, control portions

5   capable of resetting, latching, and otherwise controlling the accumulators of Figure 4, based on data received over the serial data port are anticipated herein.

Figure 5 illustrates a system, such as a general purpose computer system, that includes a display device 520 having a test module 120 built in.

10   In this implementation, a processing portion of the system can request the display device 520, which will generally be a flat panel monitor, to calculate a CRC to check the integrity of the graphics card. This request is transmitted through the graphics device 510. The calculated CRC value will be returned to the processing portion of the system through the graphics

15   device 510. This allows for increased diagnostic capabilities that can be performed by an end user, or at an end users location.

It should now be apparent that a method and system for testing video data as described herein provides advantages over previous methods and systems. For example, at speed testing is accommodated through by using a

20   small amount of test logic. In addition, no additional communication interfaces are needed by using existing serial interfaces.

CLAIMS

We claim:

1. A method of testing digital graphics data, the method comprising the
5   steps of:

        providing digital graphics data of a predetermined type having an

                expected characteristic to a graphics output port of a graphics

                system;

        receiving a representation of the digital graphics data from the

10   graphics output port;

        calculating a calculated characteristic based upon the representation of

                the digital graphics data; and

        providing the calculated characteristic to a serial interface of the

                graphics system.

15

2. The method of claim 1, wherein the expected characteristic is a calculated

        value based upon the predetermined type of digital graphics data.

3. The method of claim 2, wherein the predetermined type of digital

20   graphics data includes at least one of a red, green, and blue color

        component.

4. The method of claim 2, wherein the predetermined type of digital

        graphics data includes a horizontal synchronization component.

25

5. The method of claim 4, wherein the predetermined type of digital graphics data includes at least one of a red, green, and blue color component.

6. The method of claim 2, wherein the predetermined type of digital graphics data includes a digital graphics vertical synchronization component.

7. The method of claim 2, wherein the expected characteristic is a circular redundancy check (CRC) value.

8. The method of claim 1, wherein the predetermined type of digital graphics data is selectable.

9. The method of claim 1, wherein

the step of receiving includes receiving the representation of graphics data at a real-time graphics rate; and

the steps of calculating and providing are performed in real time with respect to the step of receiving.

10. The method of claim 1, wherein

the step of receiving includes receiving the representation of graphics data at a rate greater than 100 MHz ; and

the steps of calculating and providing are performed in real time with respect to the step of receiving.

11. The method of claim 1, wherein the serial interface is an I2C-type serial interface.

12. The method of claim 1, wherein the graphics output port includes an output port for a flat panel display.

13. The method of claim 1, wherein the serial interface is associated with the graphics output port.

14. A method of testing digital graphics data, the method comprising the steps of:

    receiving digital graphics data at a graphics port;

    determining a characteristic value upon the digital graphics data; and

5   providing the characteristic value over a serial interface of the graphics port.

15. The method of claim 14, wherein the step of providing includes the graphics port being part of a digital graphics interconnect port.

10

16. The method of claim 15, wherein the digital graphics interconnect is based on a Digital Flat Panel interconnect standard interconnect.

15 17. The method of claim 14, wherein the steps of determining and providing occur in real-time with respect to the step of receiving.

18. The method of claim 17, wherein the step of receiving includes receiving graphics data at a clock rate of at least 100 MHz.

20

19. An apparatus for testing digital graphics data, the system comprising:

    a connector to interface to a digital graphics protocol;

    a graphics data analyzer module having an input coupled to the connector, and an output; and

    a serial bus interface control module having an input coupled to the output of the graphics data analyzer module, and a serial data port coupled to the connector.

20. The system of claim 19, wherein the serial data port is coupled to the connector to transmit serial data based upon the digital graphics protocol.

21. The system of claim 20, wherein the digital graphics protocol is a Digital Flat Panel standard.

22. The system of claim 19, further comprising a power supply terminal to receive power from a peripheral component interface (PCI) bus.

23. A method of testing digital graphics data, the method comprising:

   monitoring a serial data node of a digital graphics interface to receive a

   first test indicator from a graphics controller;

   monitoring a graphics data node to receive a first graphics data from the

5   graphics controller;

   determining a first test result based upon the first test indicator and the

   first graphics data in response to receiving a first test indicator and

   the first graphics data; and

   sending the first graphics data to the serial data node in response to

10   determining the first test result.

24. The method of claim 23 further comprising the steps of::

   monitoring the serial data node of the digital graphics interface to

   receive a second test indicator from the graphics controller;

15   monitoring the graphics data node to receive a second graphics data

   from the graphics controller;

   determining a second test result based upon the second test indicator

   and the second graphics data in response to receiving a second test

   indicator and the second graphics data; and

20   sending the second graphics data to the serial data node in response to

   determining the second test result.

APPARATUS FOR TESTING DIGITAL DISPLAY DRIVER AND METHOD THEREOF

Abstract of the Disclosure

5

In a specific embodiment of the present invention, a graphics device generates digital output data in response to a known input data. The resulting digital output data has an expected circular redundancy check (CRC) value. The generated digital output data is provided to a digital

10   graphics output port associated with the graphics controller, which is thereby transmitted to a test apparatus over a digital graphics cable. The test apparatus performs an analysis on the received digital graphics data. The analysis results are transmitted back to the graphics device over a serial link of the digital display cable. The graphics device receives the transmitted

15   analysis data, which is subsequently used to determine if the graphics device is operating properly. This determination may be made the graphics device, or by a host system for further analysis.
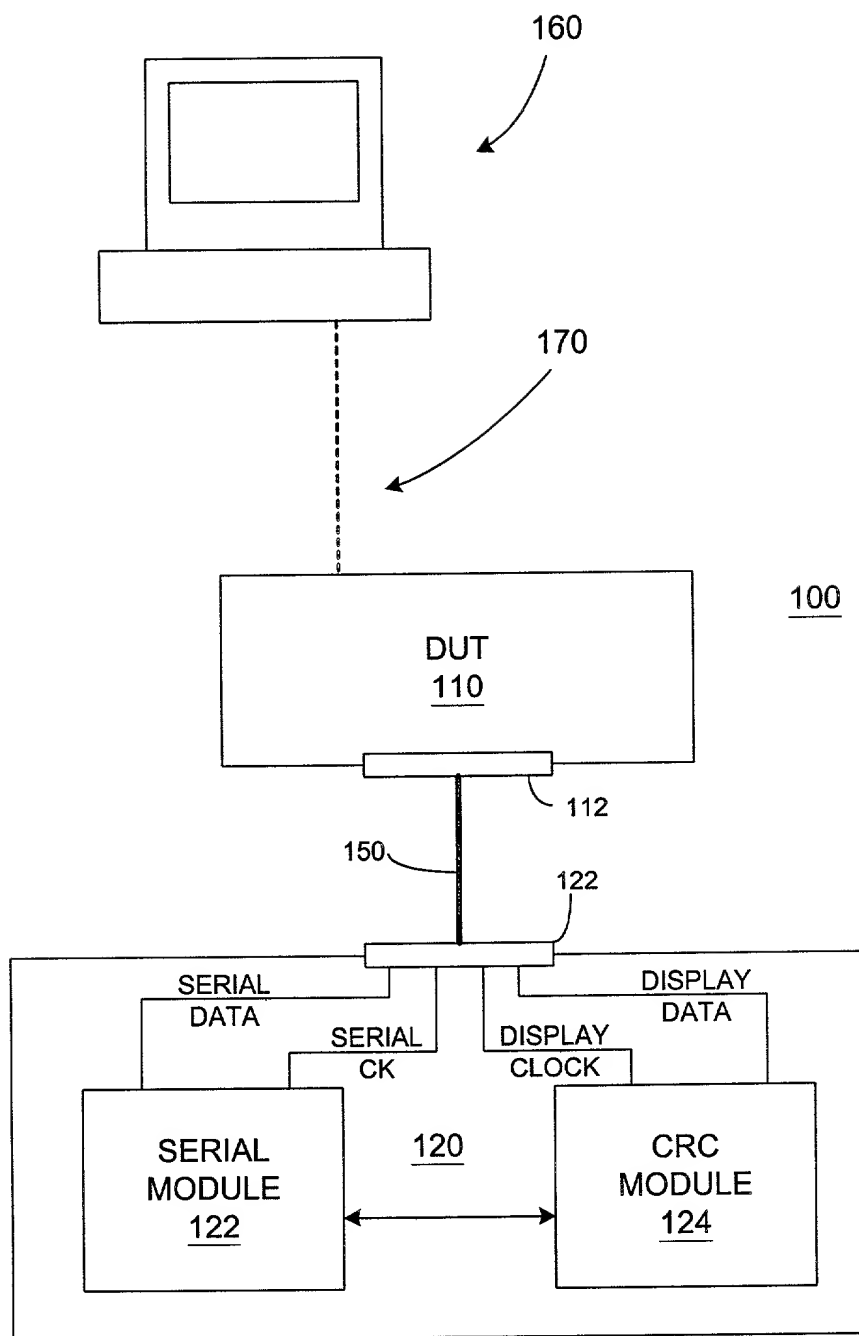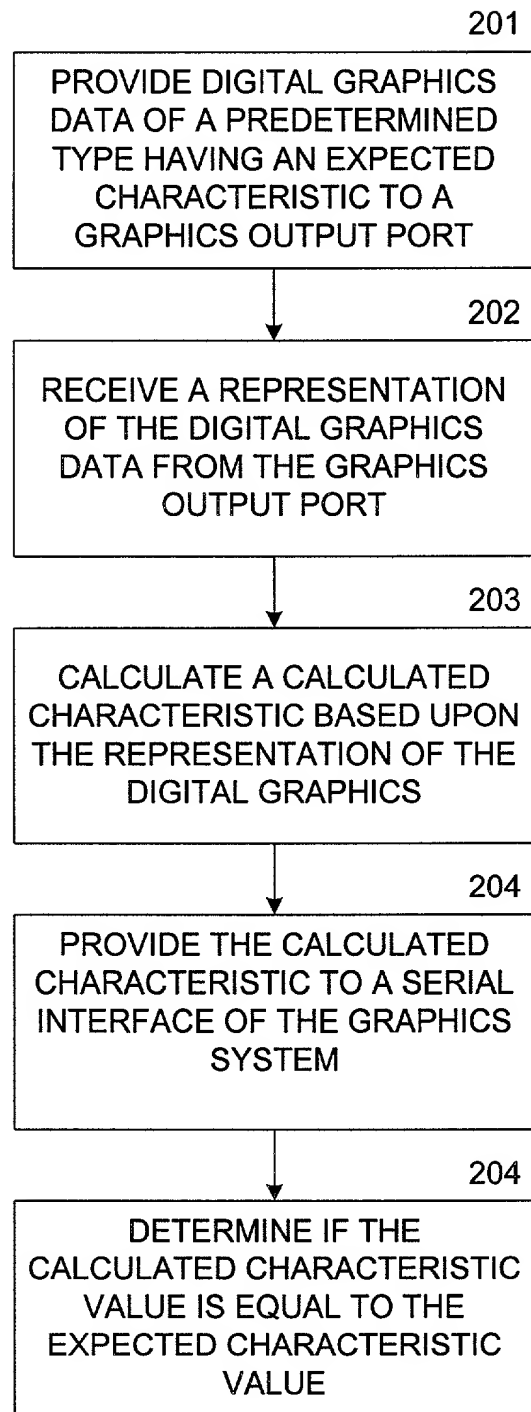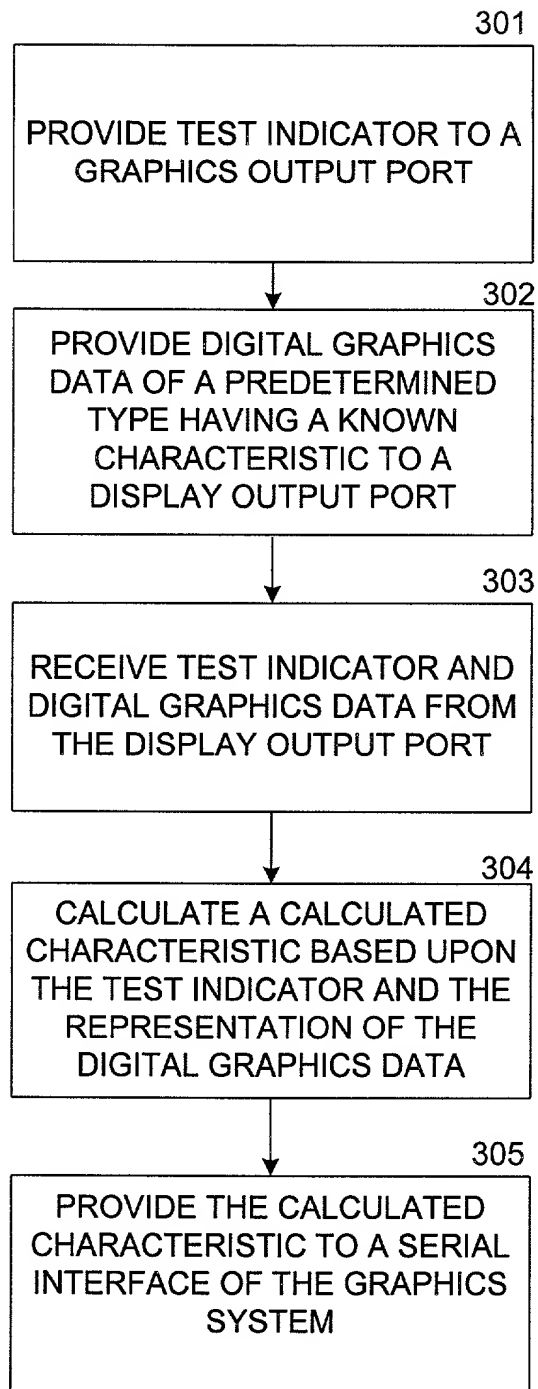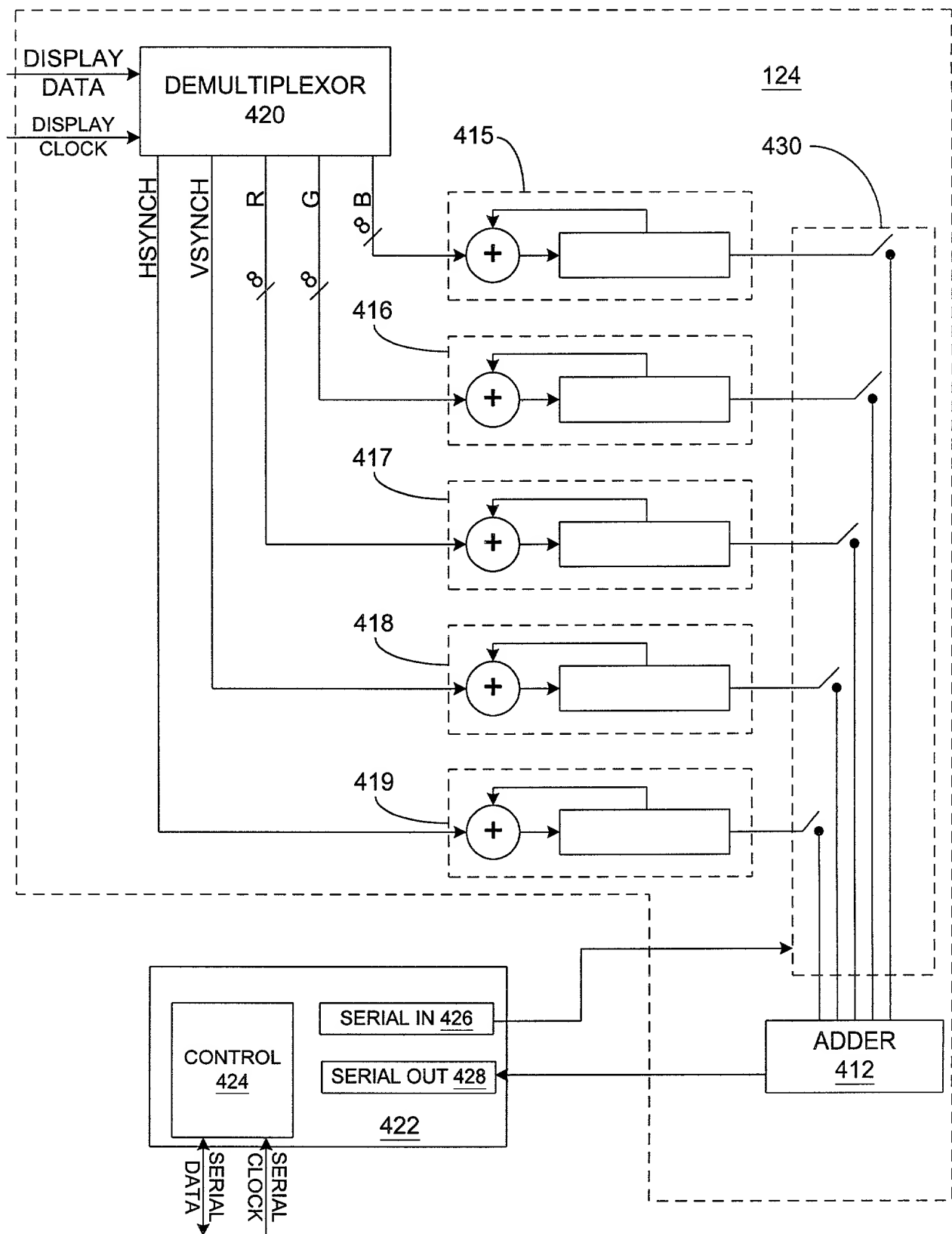
FIGURE 1

201

PROVIDE DIGITAL GRAPHICS
DATA OF A PREDETERMINED
TYPE HAVING AN EXPECTED
CHARACTERISTIC TO A
GRAPHICS OUTPUT PORT

202

RECEIVE A REPRESENTATION
OF THE DIGITAL GRAPHICS
DATA FROM THE GRAPHICS
OUTPUT PORT

203

CALCULATE A CALCULATED
CHARACTERISTIC BASED UPON
THE REPRESENTATION OF THE
DIGITAL GRAPHICS

204

PROVIDE THE CALCULATED
CHARACTERISTIC TO A SERIAL
INTERFACE OF THE GRAPHICS
SYSTEM

204

DETERMINE IF THE
CALCULATED CHARACTERISTIC
VALUE IS EQUAL TO THE
EXPECTED CHARACTERISTIC
VALUE

FIGURE 2

301

PROVIDE TEST INDICATOR TO A
GRAPHICS OUTPUT PORT

302

PROVIDE DIGITAL GRAPHICS
DATA OF A PREDETERMINED
TYPE HAVING A KNOWN
CHARACTERISTIC TO A
DISPLAY OUTPUT PORT

303

RECEIVE TEST INDICATOR AND
DIGITAL GRAPHICS DATA FROM
THE DISPLAY OUTPUT PORT

304

CALCULATE A CALCULATED
CHARACTERISTIC BASED UPON
THE TEST INDICATOR AND THE
REPRESENTATION OF THE
DIGITAL GRAPHICS DATA

305

PROVIDE THE CALCULATED
CHARACTERISTIC TO A SERIAL
INTERFACE OF THE GRAPHICS
SYSTEM

FIGURE 3

FIGURE 4

DISPLAY DEVICE

520

120

SYSTEM

510   505

FIGURE 5

DECLARATION
FOR UTILITY OR DESIGN
PATENT APPLICATION
(37 CFR 1.63)

Attorney Docket Number 0100.0000710
First Named Inventor Man, et al.
COMPLETE IF KNOWN
Application Number
Filing Date
Group Art Unit
Examiner Name

☒ Declaration Submitted with Initial Filing, OR
☐ **Declaration Submitted after Initial Filing**
(surcharge (37 CFR 1.16 (e)) required)

As a below named inventor, I hereby declare that:
My residence, post office address, and citizenship are as stated below next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

APPARATUS FOR TESTING DIGITAL DISPLAY DRIVER AND METHOD
THEREOF

the specification of which:
☒ is attached hereto.
☐ was file on (MM/DD/YYYY)   -as United States Application Number or PCT International Application
Number   and was amended on (MM/DD/YYYY)   (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.
I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES NO	
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Data (MM/DD/YYYY)

☒ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

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1

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Name	Registration Number	Name	Registration Number
Christopher J. Reckamp	34,414	John R. Garrett	27,888
Paul M. Anderson	39,896	Sally Daub	41,478
J. Gustav Larson	39,263	Ross D. Snyder	37,730
Jeffrey D. Jacobs	40,029		

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.
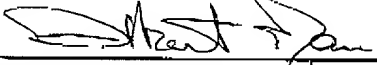
Direct all correspondence to:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

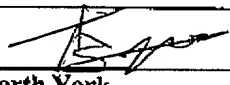| Given Name (first and middle [if any])	Family Name or Surname			
Albert Tung-chu	Man			
Inventor's Signature			Date	May 16, 2000
Residence	City: Richmond Hill	State: Ontario	Country: Canada	Citizenship: Canadian
Post Office Address	59 Mojave Crescent			
City: Richmond Hill	State: Ontario	ZIP: L4S 1P7		Country: Canada

Name of Additional Joint Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname			
Victor Herbert	Flack			
Inventor's Signature			Date	May 18/00
Residence	City: Newmarket	State: Ontario	Country: Canada	Citizenship: Canadian
Post Office Address	299 Reading Place			
City: Newmarket	State: Ontario	ZIP: L3Y 6H6		Country: Canada

Name of Additional Joint Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname			
Yuri	Lee			
Inventor's Signature			Date	May 16, 2000
Residence	City: North York	State: Ontario	Country: Canada	Citizenship: Canadian
Post Office Address	5 Concorde Place, #2210			
City: North York	State: Ontario	ZIP: M3C 3M8		Country: Canada

☐ Additional inventors are being named on the _____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.

2